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EVIDENCES OF DISTURBANCE DURING THE DEPOSITION OF THE BURLINGTON LIMESTONES.

BY F. M. FULTZ.

In a general way the lithological characters of the Burlington limestones, including both the lower and upper divisions, are the same. It is true that some layers are more compact than others, some more massive and a few are even crystalline enough in texture to imperfectly resemble marble, yet they all owe their origin to the same source. The material comprising them is almost wholly crinoidal. To such an extent is this true, that, with the exception of a very few layers, it is scarcely possible to find a cubic inch of rock that does not show its crinoidal origin. There are a few layers of shales, clays, etc., but for the most part they are quite thin and form but a very small part of the whole. However, they are deserving of some attention and I shall take occasion to refer to at least one or two of them specifically.

What I will endeavor to point out in this paper is, that during the deposition of these limestones, there were some periods of disturbance. The evidences of such disturbance are: (1.) The more or less abrupt changes in fossil forms. (2.) Change in lithological characters. (3.) Erosion and unconformability. I wish to speak more particularly about erosion, but will first say a few things about the change in fossil forms.

I have already mentioned that the prevailing life was crinoidal. Not counting synonyms there are probably between 350 and 400 species of crinoids found in the Burlington limestones. The greatest number occurring in any one layer is not more than one-fourth of the whole; usually much less than that. Besides, many of these species do not lap over each other and there are several breaks where not a single species bridges over the change from one stratum to the next higher, without some difference in form. So universal a change in fossil forms would indicate a sudden change in climatic conditions, and since in each succeeding stratum there seems to be no diminution, either in number of species or individuals —the genera remaining nearly the same and the species closely allied to former existing ones—there must have been a comparatively early return to the former conditions. Of course, while all life may have been extinguished at one point, no doubt it flourished in full vigor at no very great distance away, and as soon as the conditions again became favorable it once more occupied its old ground. If the period of interruption was short, or the area of disaster not too widely spread, the new forms of life would not differ much from the old. But if the area of disaster was extensive or the period of interruption prolonged, then the result would show the extinction of species and the beginning of new ones. As a rule species do not gradually die out, *they are killed off*. At least this is the apparent fact if the

study of life is confined to a single locality. Of course to try to make the rule general would be to deny the theory of evolution. Since life is largely dependent upon climatic conditions, it follows that a sudden change in these conditions means a sudden change of life. So that, if in passing from one stratum to another, we find a considerable change in fossil forms, we must accept it as evidence of change of conditions under which the depositions took place.

Now, as I have already stated, we find such comparatively marked changes of fossil forms at several places in the Burlington limestones. Knowing such to be the case I have been on the lookout for further evidences of changes in the way of erosion, unconformability, etc.

It has generally been accepted that the deposition of the whole lower Carboniferous group in southeastern Iowa was uninterrupted. I quote from White, Geol. of Iowa, 1870. Vol. 1, page 202, "The accumulation of the strata which compose all the formations of the sub-Carboniferous group in southeastern Iowa, from the lower Burlington limestone to the Saint Louis limestone, inclusive, was evidently uninterrupted." And this seems to have been the generally accepted idea. White admits the change of fossil forms, but limits the changes to siliceous beds only, and advances the theory that life died out owing to the waters becoming charged with siliceous material. He makes no statement of the fact that some of the most distinct lines of change are at intervals between the lower and upper flint beds, and also below the lower one. It is most likely, too, that the flint beds mark *gradual* rather than *sudden* eras of change. However, of this I will say more later.

White gives 50 feet as the thickness of each division of the Burlington limestone, making 100 feet for the two. Now, at Burlington, the typical locality, the two together measure scarcely more than 50 feet. Of course there are deposits at other places in southeastern Iowa belonging to the Burlington series which are not represented at Burlington itself. And no doubt the complete section of the two divisions together would reach 100 feet. Now, while there was a cessation of deposit and corresponding absence of life in one locality, the rock building was steadily going on at other points not far distant. So that while 50 feet may be the maximum thickness at any one locality, the total thickness of the complete series might easily be 100 feet.

The lower division of the Burlington limestones gives a more continuous section than the upper. As to fossil forms there are some pretty distinct lines of change, but so far I have been unable to find any evidence of a corresponding era of disturbance. There is no positive evidence that there was a cessation of deposition The surfaces of some of the strata have a water-worn appearance, but no erosion has so far been discovered. It would not surprise me, however, to hear of such evidence having been found. The lower half of the lower division is well-bedded and seems to have been laid down in comparative quiet waters. The upper half is poorly bedded and contains many flint bands and irregular pockets of coarse sandy clay. It shows much disintegration.

As to the origin of these flint bands there has been a great deal of speculation, but so far no very satisfactory theory has been advanced. An examination of the beds will show that life did not suddenly cease with the advent of siliceous material. Frequently layers are found which are literally covered with fossils. My attention was first called to this fact by Mr. Chas. R. Keyes about two years ago while examining the Burlington limestone at Louisiana, Mo. I have since found it to be true at Burlington and other places. The fossils are always fully solicified,

although perfect in form and detail. Also they are usually very small, not exceeding one-fourth the size of individuals of the same species found in the associated limestone layers. So White's statement that the conditions seemed to have been unfavorable for the support of life, is true, at least in part. But I think the flint beds contain much more evidence of life than he has given them credit for. There is no doubt, however, that the flint beds of both the upper and lower divisions mark eras of change in fossil forms. It would be strange if they did not, considering that the minimum thickness of either is fully ten feet. But they do not furnish the most distinct lines of change inasmuch as some of those in the limestone takes place in passing from one stratum to the one directly superimposed.

In the upper division I have found direct evidence of disturbance and erosion at one of these lines of change in fossil forms. Everywhere in the vicinity of Burlington, where the upper division is found, there occurs, well down toward the base, a stratum of heavy bedded white limestone. It is about six feet in thickness and generally underlying it there is either a thin layer of blue clay or friable, yellow, sandy limerock. Immediately overlying it there is uniformly found a bed of tough blue shale. I had frequently noticed the upper surface of the limestone layer as exhibiting a water-worn appearance and so was not surprised when I found direct evidence of erosion. This discovery was made in the Cascade quarry in the south part of the city limits of Burlington. In this quarry nearly the whole depth of the Upper Burlington limestone is worked. The massive white layer spoken of is here between 5 and 6 feet in thickness and furnishes a goodly part of the rock taken out.

The Cascade ravine is about half a mile in length and enters the Mississippi river at right angles. These quarries are situated about a quarter of a mile back from the river and on both sides of the ravine. It was in the one on the south side that the discovery was made. This quarry is on both sides of a short, but deep, lateral ravine, the bottom of which is several feet lower than the stratum of white limestone. In working off the corner between the main and lateral ravines, the white limestone layer was found to be much eroded. The erosion is lateral rather than surface and occurs on the side toward the lateral ravine. The layer of blue shale is deposited directly upon the eroded surface and conforms to all the inequalities, some of which are quite abrupt. One bench of the eroded surface amounts to fully two feet and yet the blue shale covers this without a break. The blue shale itself is capped by well-bedded limestone.

This is direct evidence of erosion in the early part of the deposition of the upper Burlington limestone. An interesting fact is developed that the present drainage system was probably fixed at that early date. The position of the eroded surface of the white limestone layer, and the inclination of the directly superimposed beds all indicate that the lateral ravine had its beginning at a time at least as early as that. Of course the principal ravine must have existed to furnish an outlet. Along the banks of the principal ravine I have never seen the white limestone layer exposed, but have no doubt it would exhibit the same erosion as found along the lateral ravine. All the superimposed strata exhibit a decided inclination towards the ravine, which would tend to confirm the theory.

In conclusion, I would state that there seems to be no doubt whatever that the deposition of the Burlington limestones was not continuous. I expect to see other evidence of this fact discovered in the near future.